

## TITLE OF INVENTION

**Graphite / Carbon fiber and wood neck for a stringed musical instrument using force vector controlled geometry.**

## CROSS-REFERENCE TO RELATED APPLICATIONS

### References Cited

#### US Patent Documents

4074606	Oct. 1976	Fender	84/293
4846039	Jul. 1989	Mosher	84/293
4951542	Aug. 1990	Chen	84/293
5616873	Apr. 1997	Fishman et al	84/293
5990396	Nov. 1999	Lasner	84/293
6087568	Jul. 2000	Seal	84/193

#### Other References

##### USPTO

disclosure document number 491024

provisional utility application number 60/278,985 (confirmation number 9387)

Smith, Zeke.

Understanding aircraft composite construction: basics of materials and techniques for the non-engineer / by Zeke Smith.

Napa, CA : Aeronaut Press; Gilsum, NH : Order from Pathway Book Service, ©1996.

Flabel, Jean-Claude.

Practical stress analysis for design engineers : design and analysis of aerospace vehicle structures / Jean-Claude Flabel. 1 st ed.

Hayden Lake, Idaho: Lake City Pub. Co., ©1997.

Locken, Hal and Hollman, Martin Designing with core.

Lambie, Jack

Composite Construction

## STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

## REFERENCE TO A MICROFICHE APPENDIX

Not Applicable

## BACKGROUND OF THE INVENTION:

**Field of Invention:** This invention relates to a stringed musical instrument and in particular to instrument components such as the neck and central body structure

A few guitar builders and manufacturers have used carbon fiber with varying degrees of success. One such prior art design (US Patent # 5,990,396) has a central T-shaped extruded stiffening bar preferably of graphite fibers which, alone, carries the load imposed by a plurality of strings, and the wood is not a structural element thereof. One other prior art design (US Patent # 5,616,873) uses a fingerboard made of graphite fibers in the place of the traditional prior art fingerboard. This serves as the main structural element while using a wire to counteract the tension load imposed by a plurality of strings similar to another prior art design (US Patent # 4,074,606). It specifies a soft wood, and the wood is not a structural element. Another prior art design (US Patent # 4,951,542) using graphite, however, this patent pertains to the molding process, and does not relate to an engineered design, nor does it specify any particular orientation of the graphite fibers, also heat and pressure are used. One other prior art design (US Patent # 6087568) using a graphite and glass composite to cast a complete neck assembly, of which wood is not a structural element.

Graphite, or carbon fiber (one and the same) is only rayon extruded under extreme heat and pressure. This changes its molecular structure on a subatomic level. It is a material that lends itself to highly engineered applications with its high strength and stiffness coefficient (it is six times stronger than chrome-moly steel). It is a composite material that offers excellent values of strength in compression as well as tension.

In order to capitalize on this attribute the structure must be designed, and the workmanship must be of such quality, so as to apply the fibers in a perfectly straight line with reference to the load being placed on it, carried by it, and distributed into other structures. When this is achieved, a minimal amount of graphite can be used. (The preferred embodiment of the invention uses approximately 60 cubic centimeters of material.)

Also, the magnitude of engineering should be considered. Many factors weigh into a design of this type. Such as string tension values, displaced tension fields, semi-tension fields, column loads, and load terminations, etc.

On the other hand arbitrary over use of graphite will produce a neck that will not resonate

the desired tone, and be so stiff that any string orbit relief is impossible. The choice of a matrix strong enough to capture this material is paramount.

A true "composite" structure must be engineered and designed as a whole. This one is constructed from carbon fiber and wood. In the preferred embodiment it should be manufactured by hand, and not be extruded or mass produced, and it requires very skilled labor .

Some prior art designs place a number of small graphite rods in the node region of the structure (Center of Neck). This area is where the structure yields, or flexes the absolute least. In order to utilize this material best, and achieve a good strength to weight ratio the structural element (graphite) must be placed as far away from the node region as possible.

This instruments neck design is of composite sandwich / stressed skin truss type. It utilizes a high-density wooden core to bear against. From an engineering standpoint the wood's primary function is as an inter-laminar sheer and compression core. Which holds the graphite in its proper place so that it functions as designed, and transfers opposing loads in a semi-tension field from one point to another, and to withstand the crush loads imposed in the region between the compression spar and the tension spar.

From a musical standpoint the wood needs only to resonate the desired tone. It is still a crucial element to the structure.

### **BRIEF SUMMARY OF THE INVENTION**

A composite structure, engineered using force vector controlled geometry, constructed around a high density structural wood core with an outer stressed skin truss structure made of carbon fiber cloth and epoxy resins, and containing therein compression and tension spar caps made of graphite.

I believe this is the first embodiment of this type technology applied to a stringed musical instrument, and with proper application of these materials there is little change in the relative mass to density ratio of the original wood. Therefore, tone and the natural resonance of the wood are preserved as much as possible, while tremendous gains in strength, stiffness, and stability are achieved.

Preliminary tests of the invention reveal that it is at least twelve times stiffer than a conventionally constructed (prior art) wooden neck. It has very little thermal creep and distortion in comparison to a (prior art) wooden neck, and although subjective, the tonal differences are insignificant.

## BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Fig. 1 is a perspective view of the stringed instrument in accordance with the invention.

Fig. 2 is a side view of the composite structure of the neck assembly in accordance with the invention.

Fig. 3 is a top view of the composite structure of the neck assembly in accordance with the invention.

Fig. 4 is an exploded side view of the structure of the neck assembly taken along line A-A of figure 1 with item 6 being a frontal view of same

Fig 5 is an exploded cross sectional view of the structure of the neck assembly taken along line A-A of figure 1.

Fig 6 is a cross sectional end view of the complete structure of the neck assembly taken along line A-A of fig 1.

Fig. 7 is an exploded perspective view of the individual components of the neck assembly structure taken along line A-A of figure 1.

Fig 8 is a geometric force vector diagram with reference to the engineering of the invention.

## DETAILED DESCRIPTION OF THE INVENTION:

**A:** Referring to FIG 1 a guitar constructed in accordance with the present invention has a neck and central body portion extending along **L** (shown in FIG 2) with a wood core **3** (shown in FIG 4,5,6,7) of hard maple or mahogany with a specific gravity not less than .36, a grain run out of not more than one in 15, and at least six annular rings per inch. Machined to the desired semicircular cross-sectional shape FIG 6 common to the back of a (prior art) wooden neck, and undersized on all applicable surfaces approximately .032 inches to accommodate the required thickness of graphite / carbon fiber cloth and resin **2 and 5** (Shown in FIG 4,5,6,7).

**B:** On the face of the neck FIG 3 between the traditional (prior art) wood fingerboard **1** (shown in FIG 2,4,5,6,7) and the semicircular section described in "A" a carbon / graphite compression spar **2** (shown in FIG 4,5,6,7) is constructed ( for string tension values between 55 and 85 total lbs.) Using one ribbon of Uni-Directional Aerospace grade graphite **10** (shown in FIG 7) .012 inch thick, and two layers of aerospace grade AS282 **8 and 9**( shown in FIG 7) or equivalent. It is laminated using Gougeon Brothers / West System™ Slow 105-206 laminating resin or equivalent (fast set resins are not permitted as they do not allow sufficient wick time to properly lock up the fibers). For string tension values above 85 lbs., but not to exceed 150 lbs., two layers of Uni-Directional Aerospace grade graphite ribbon totaling .024 inches thick shall be used in conjunction with two layers of AS282 or equivalent as prescribed in this paragraph.

**C:** On the side opposite the compression spar 2 (shown in FIG 4,5,6,7) at the centerline of the semicircular section described in "A" a tension spar 4 (shown in FIG 4,5,6,7) shall be installed and bonded (for string tension values between 55 and 85 total lbs.) The tension spar 4 shall be

.125 by .375 inches and at least 17 inches in length. It will be fabricated with only Uni-Directional graphite. For string tension values above 85 lbs., but not to exceed 150 lbs., the cross-sectional area of the tension spar 4 shall be 150% of the previously described dimensions and at least 17 inches in length.

**D:** At this point the tension spar 4 (shown in FIG 4,5,6,7) is faired into the semicircular structural wood core 3. Then two layers of AS282 Bi-Directional 5 (shown in FIG 4,5,6,7) are placed on the outer portion of the back of the wood core 3 the fibers are oriented at 45° to the centerline of the longitudinal axis of the neck wooden core 3, and laminated with the resin described in "B". This stressed skin 5 (shown in FIG 4,5,6,7) serves to provide a torsional rigidity about the entire structure, and to pick up semi-tension loads from the tension spar 4 along with the active crush loads generated in the region between the compression spar 2 and the tension spar 4 and redistribute said loads into the 45° fibers of the outer skin structure 5 as a counteracting force upon the compression spar 2 (This is Force Vector Controlled Geometry).

**E.** A .225-inch slot will be machined into the center of the compression spar 2 and wooden core 3 at a depth to accommodate the string orbit relief control mechanism 7 (shown in FIG 5,6), but not excessively into the underlying tension spar 4 (a maximum cut into the tension spar of .020 inches is allowed). This mechanism 7 is necessitated by the design which is so stiff that if the player desires string orbit relief it must be put in by turning the adjuster mechanism 7 in a counterclockwise direction, not taken out as is common with traditional (prior art) wooden neck designs.

**F.** The adjustment mechanism 7 shall be installed and the (prior art) fingerboard 1 of desired wood shall be bonded to the compression spar 2 outer surface using 3M ScotchWeld™ adhesive or equivalent. Using clamps and a suitable fixture so as to maintain surface straightness of the (prior art) fingerboard 1 within  $\pm .003$  inches.

**G.** The scored peel-ply finish may be sanded lightly, but not excessively. The carbon / graphite outer skin 5 shall not be cut into by means of sanding, as this weakens the structure. The carbon / graphite exterior shall be finished with a high solids clear such as PPG Diamond Coat™ or equivalent. Containing UV blocking compounds with a maximum of four applied coats. (An aesthetic benefit is an attractive "snake-skin" type appearance.) Mass production high build FeatherFill™ type primers / surfacers are not permitted on the neck as they alter and deaden the tone of the underlying wood.

**H.** FIG 8 is a geometric force vector flow diagram illustrating the loads imposed by the plurality of strings F and the resulting radial load E on the entire structure, and how the design of this invention redistributes said loads. The individual loads and vectors created by string tension are: compression load A carried by 2 (FIG 4,5,6,7), a semi-tension load B carried by 4 (FIG 4,5,6,7), a crush load C generated by the opposing forces of A and B and carried by 3 (FIG 4,5,6,7), and distributed into the outer skin truss 5 (FIG 4,5,6,7), with D representing the redirection of loads A, B, and C as opposing forces to the original compression load A.

### Notes:

1. With reference to the longitudinal centerline of the structure all graphite and carbon fiber **2, 4, and 5** (shown in FIG 4,5,6) **4, 5, 8, 9, and 10** (shown in FIG 7), shall be oriented at right angles, parallel, or at  $45^{\circ} \pm 5^{\circ}$  no other deviations are acceptable.

2. Steps "C" and "D" shall be accomplished with the neck being held in or upon a fixture which maintains absolute straightness in the plane where the (prior art) fingerboard **1** attaches to the compression spar **2** within a tolerance of  $\pm .002$  inches. It shall be held here for a minimum of 72 hours from the time of the application of the resin ( described in material specification section appendixes A).

3. A peel-ply may be used. Heat or acceleration is not permitted. The temperature of the lay up shall be maintained between  $70^{\circ}$  F and  $100^{\circ}$  F for the duration of the 72 hours. Pre-pregs and / or autoclave shall not be permitted as the heat process will affect the moisture content of the wood core, causing it to steam out into the resin matrix during curing later contributing to delamination.

4. This design has been engineered to provide a minimal alteration in the mass to density ratio of the wooden structure, with maximum stiffness, minimal thermal creep, and excellent preservation of the wood tone and resonance. The preferred embodiment of the invention employs approximately 60 cubic centimeters of total material in a typical six-string 25.5 inch scale guitar neck.

## Appendix A

### Material Specifications

1: Carbon fiber cloth Aerospace grade AS282 BID, manufactured by Hexel Chemical Corporation, plain weave 12.5 x 12.5, 5.7 oz.

2: Uni-Directional graphite tape Aerospace grade .012 inch thick, 54,000 lbs. strength per inch of width.

3: .125 x .375 x 17-inch Uni-Directional graphite rod.

4: Acer Saccharum (Hard Maple) or Swietenia Macrophylla (Mahogany) with a specific gravity not less than .36 and maximum grain slope of one in 15 and at least six annular rings per inch.

5: 3M ScotchWeld™ 2216 B/A structural adhesive.

6: Gougeon Brothers / West System™ 105-206 Slow laminating resin.

### Note:

Carbon fiber / graphite, adhesives, and resins may be of different brand as long as they are of the same grade and quality and a directly acceptable equivalent replacement.